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Man

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[54] **ADAPTIVE NETWORK PROTOCOL INDEPENDENT INTERFACE**

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[51] **Int. Cl.**[6] **H04L 29/06**

[52] **U.S. Cl.** **395/500**

[58] **Field of Search** 395/500, 200.15, 395/200.02, 200.03, 117, 602, 614, 284, 285, 286, 200.19, 200.2, 200.1; 370/389, 401, 455

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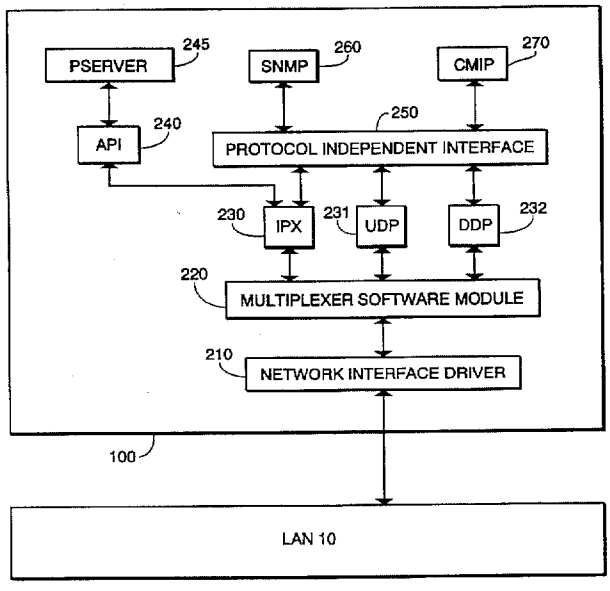
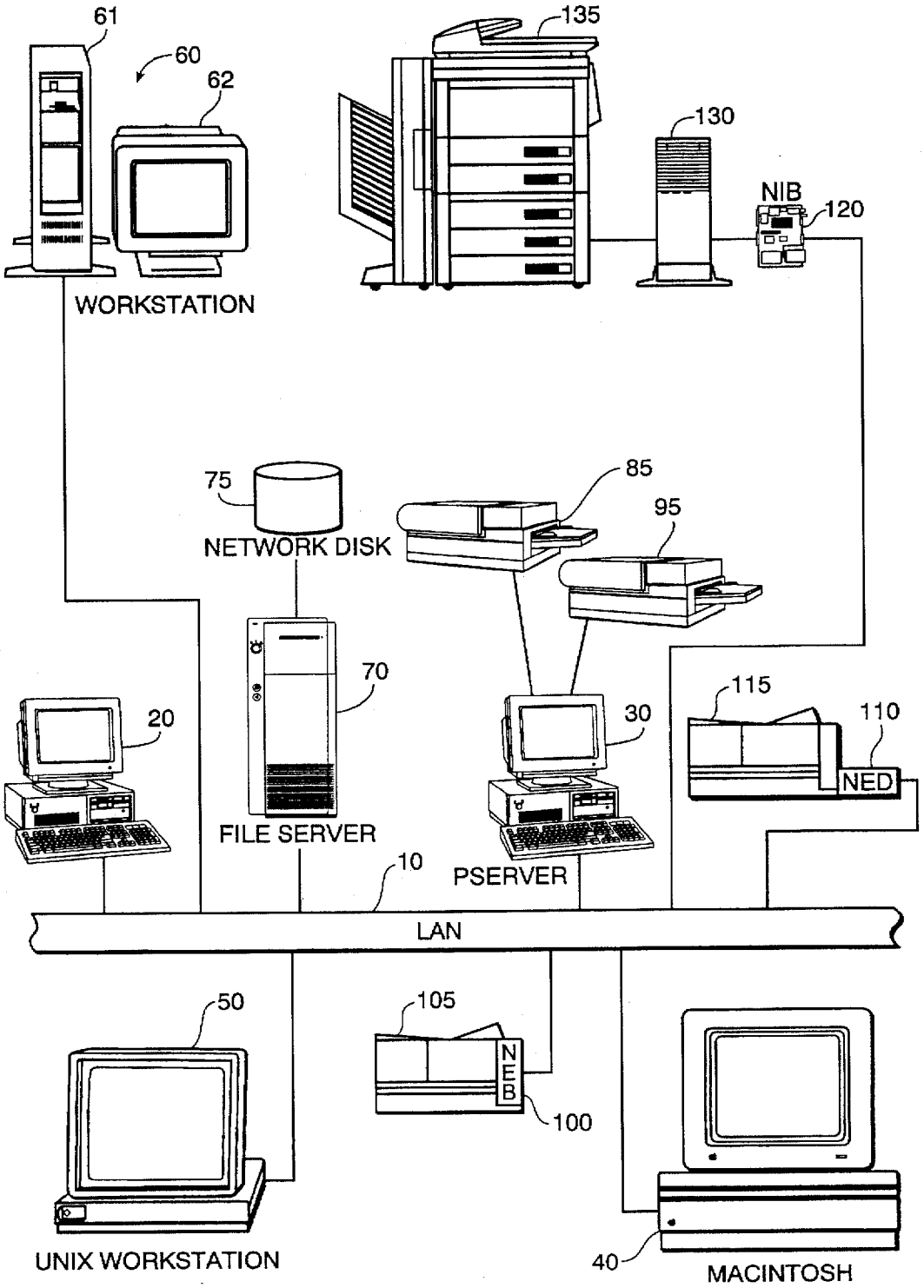
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] **ABSTRACT**

A protocol independent method of transmitting a data packet from a first application program executing on a first device which is interfaced to a LAN to a second application program executing on a second device which is interfaced to the LAN. A protocol independent interface (PII) program is initialized which determines which protocols are available for use, assigns an access line to each protocol that is available for use, assigns an access ID to the first application program, and creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data. A data packet is sent to the PII program together with the access ID of the first application program and a destination ID for the second application program, and one of the available protocols is selected to transmit the data packet. A block of protocol specific information is retrieved from the mapping information based on the access ID of the first application program and the access line corresponding to the selected protocol, and a transmission packet is formed which includes the data packet, the destination ID, and the retrieved block of protocol specific information. The transmission packet is then transmitted via the LAN.

43 Claims, 12 Drawing Sheets




61
60
62
WORKSTATION
135
130
NIB
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75
NETWORK DISK
85
95
70
20
FILE SERVER
30
PSERVER
115
110
NED
10
LAN
50
105
NEB
100
UNIX WORKSTATION
40
MACINTOSH

FIG. 1

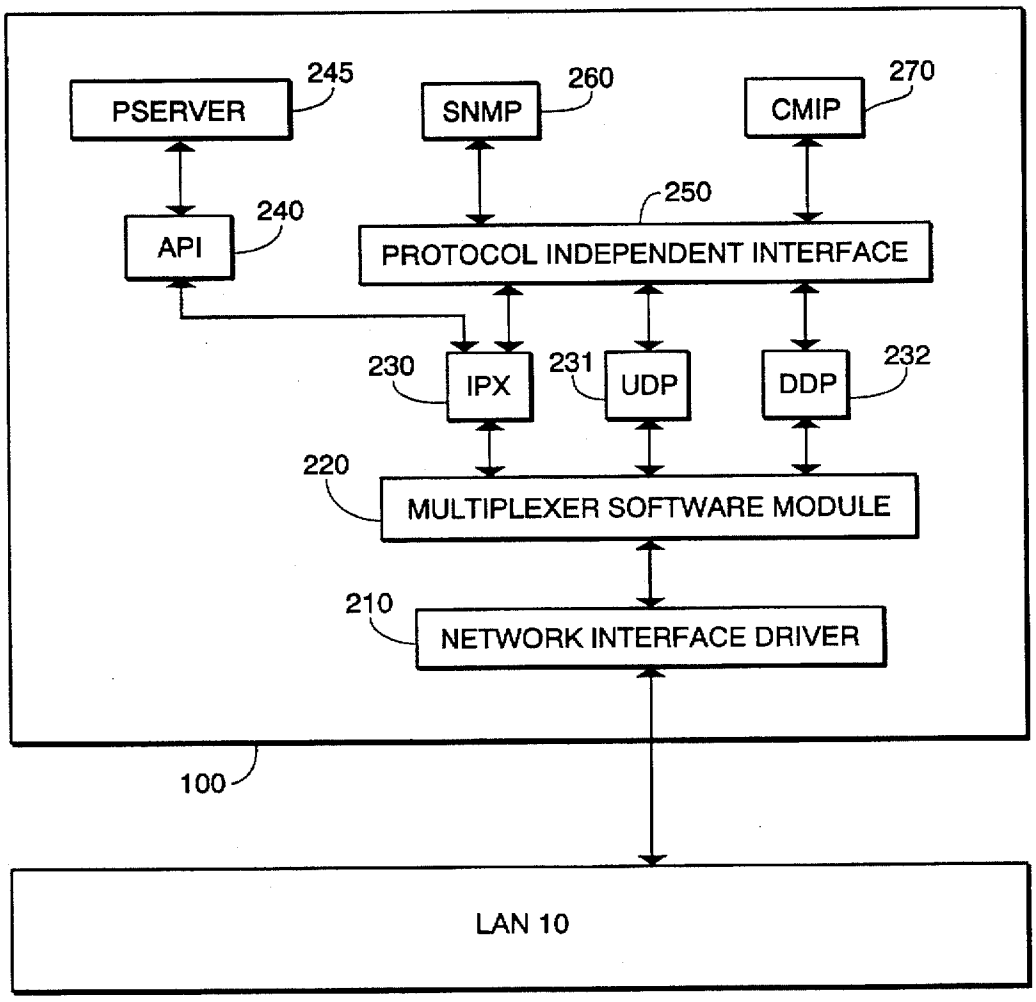
PSERVER
245
SNMP
260
CMIP
270
API
240
250
PROTOCOL INDEPENDENT INTERFACE
230
IPX
231
UDP
DDP
232
220
MULTIPLEXER SOFTWARE MODULE
210
NETWORK INTERFACE DRIVER
100
LAN 10

FIG. 2

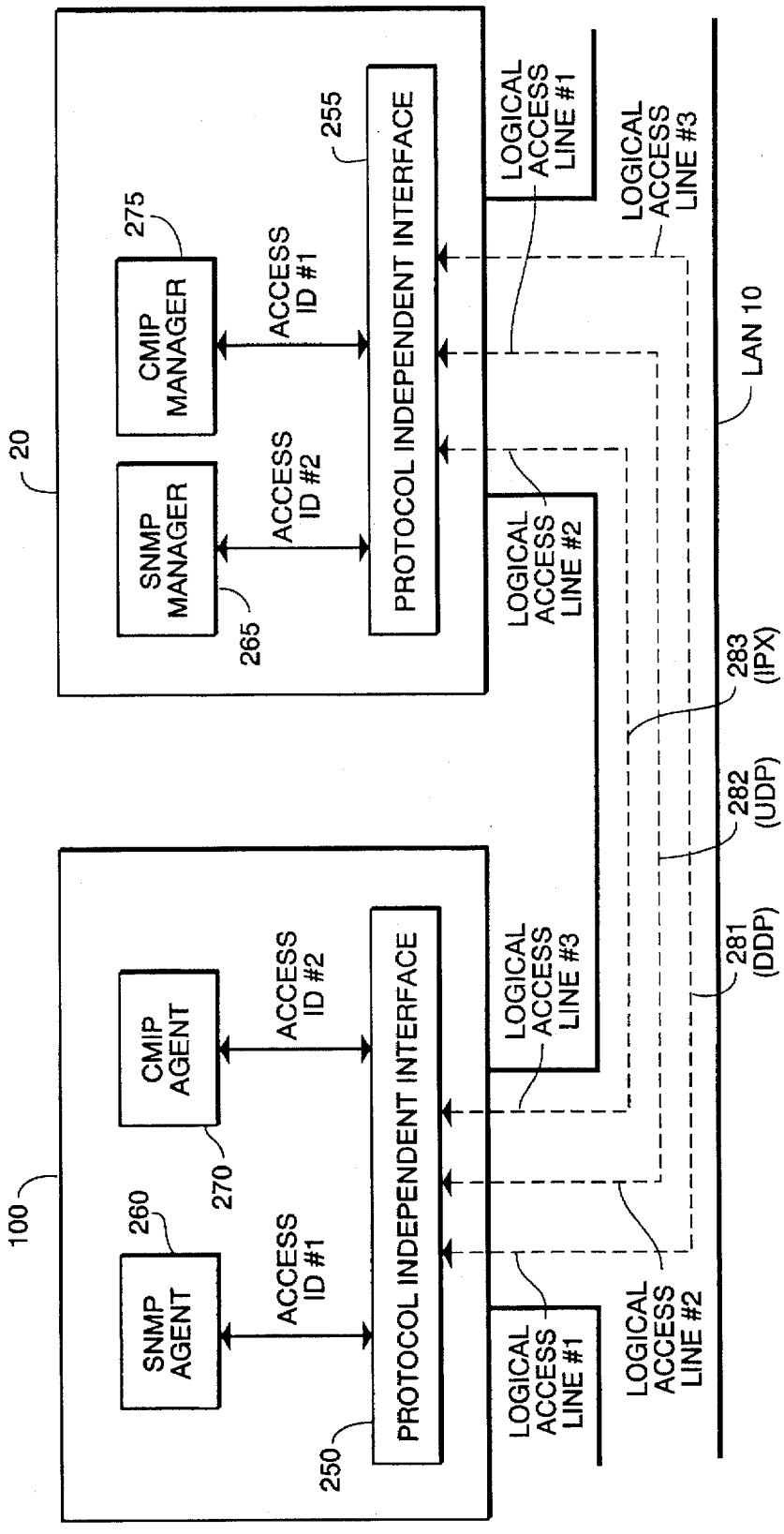
20
CMIP MANAGER
275
SNMP MANAGER
265
ACCESS ID #1
ACCESS ID #2
255
PROTOCOL INDEPENDENT INTERFACE
LOGICAL ACCESS LINE #1
LOGICAL ACCESS LINE #2
LOGICAL ACCESS LINE #3
LAN 10
283 (IPX)
282 (UDP)
281 (DDP)
100
CMIP AGENT
270
SNMP AGENT
260
ACCESS ID #2
ACCESS ID #1
250
PROTOCOL INDEPENDENT INTERFACE
LOGICAL ACCESS LINE #3
LOGICAL ACCESS LINE #1
LOGICAL ACCESS LINE #2

FIG. 3

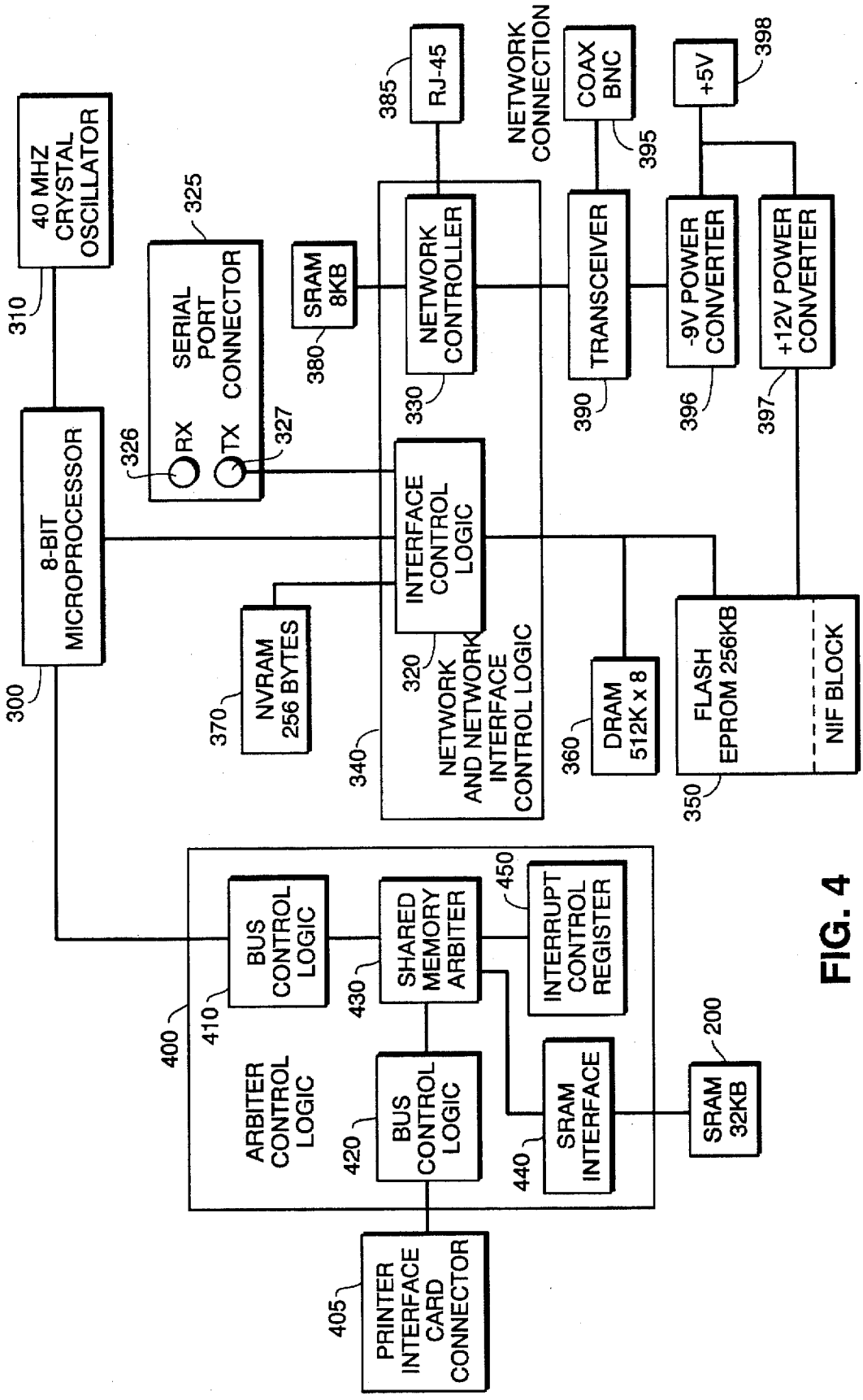
40 MHZ CRYSTAL OSCILLATOR
310
8-BIT MICROPROCESSOR
300
SERIAL PORT CONNECTOR
325
RX
TX
326
327
SRAM 8KB
380
NETWORK CONTROLLER
330
RJ-45
385
NETWORK CONNECTION
COAX BNC
395
TRANSCEIVER
390
+5V
398
-9V POWER CONVERTER
396
+12V POWER CONVERTER
397
INTERFACE CONTROL LOGIC
NVRAM 256 BYTES
370
320
NETWORK AND NETWORK INTERFACE CONTROL LOGIC
340
DRAM 512K x 8
360
FLASH EPROM 256KB
NIF BLOCK
350
ARBITER CONTROL LOGIC
400
BUS CONTROL LOGIC
410
SHARED MEMORY ARBITER
430
450
INTERRUPT CONTROL REGISTER
BUS CONTROL LOGIC
420
SRAM INTERFACE
440
SRAM 32KB
200
PRINTER INTERFACE CARD CONNECTOR
405

FIG. 4

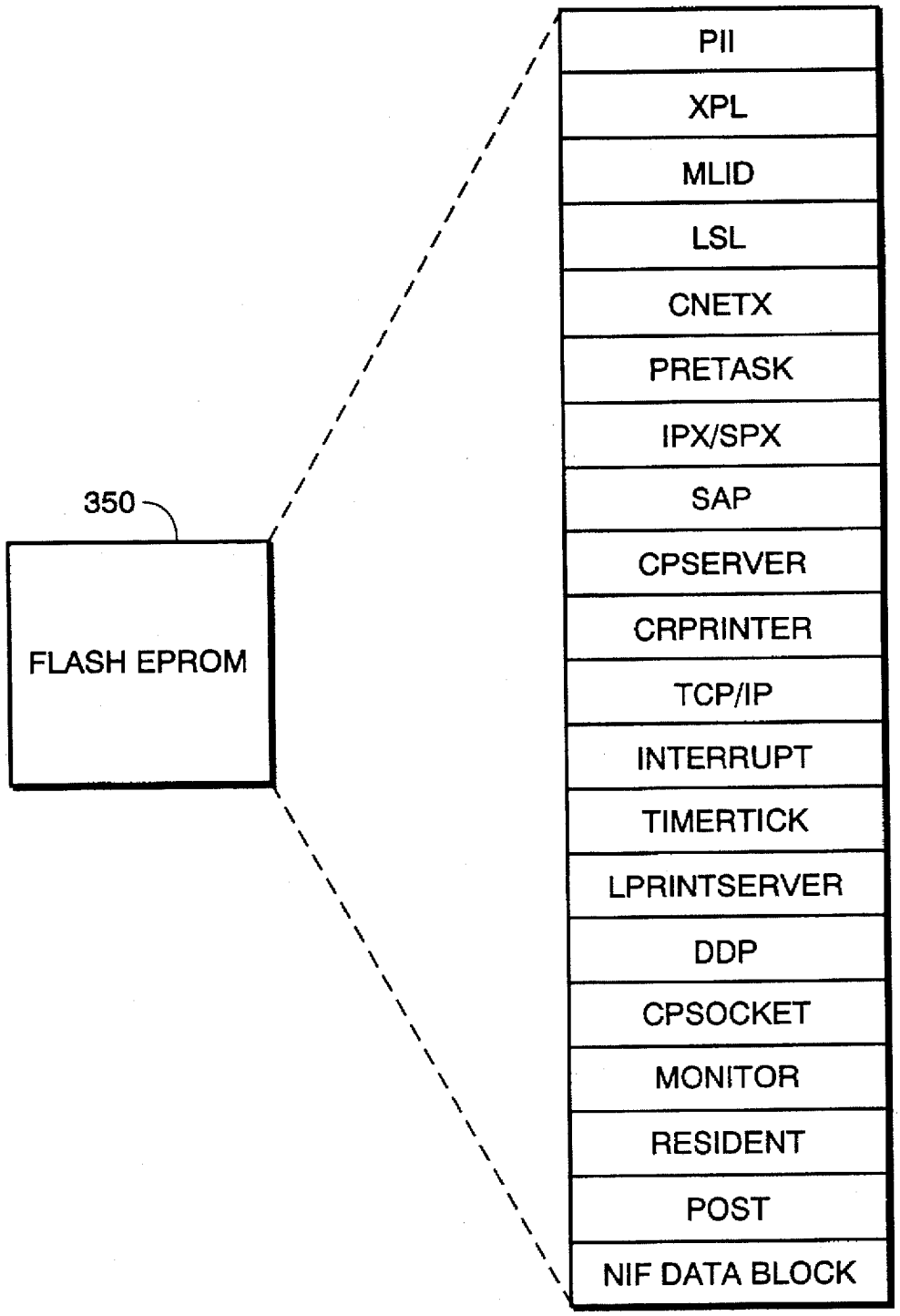
350
FLASH EPROM
PII
XPL
MLID
LSL
CNETX
PRETASK
IPX/SPX
SAP
CPSERVER
CRPRINTER
TCP/IP
INTERRUPT
TIMERTICK
LPRINTSERVER
DDP
CPSOCKET
MONITOR
RESIDENT
POST
NIF DATA BLOCK

FIG. 5

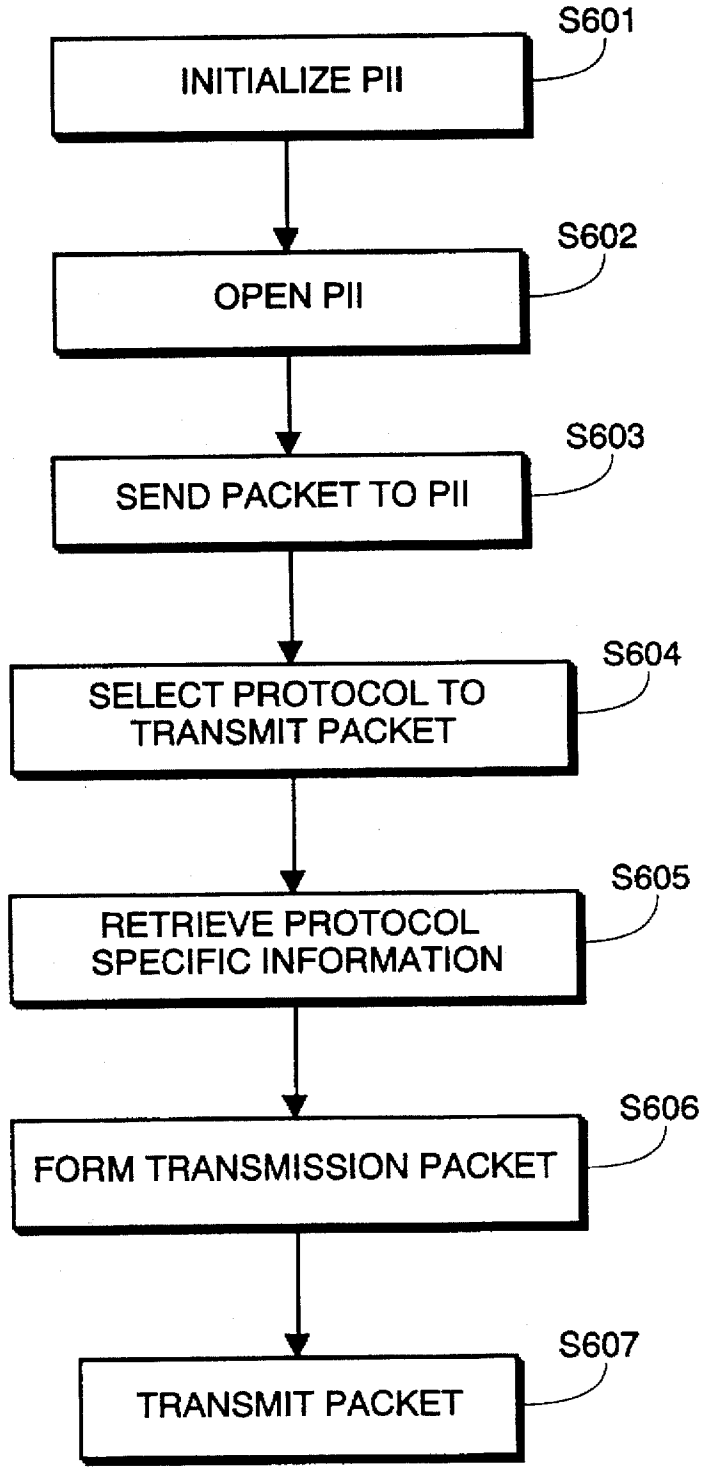
S601
INITIALIZE PII
S602
OPEN PII
S603
SEND PACKET TO PII
S604
SELECT PROTOCOL TO TRANSMIT PACKET
S605
RETRIEVE PROTOCOL SPECIFIC INFORMATION
S606
FORM TRANSMISSION PACKET
S607
TRANSMIT PACKET

FIG. 6

FIG. 7A

PROTOCOL	ACCESS LINE #
UDP	1
IPX	2
DDP	3

FIG. 7B

PROTOCOL	ACCESS LINE #
UDP	2
IPX	3
DDP	1

FIG. 8A

PROGRAM	ACCESS ID #
CMIP MANAGER	XXXX1
SNMP MANAGER	XXXX2

FIG. 8B

PROGRAM	ACCESS ID #
CMIP AGENT	YYYY2
SNMP AGENT	YYYY1

FIG. 9A

902

ACCESS ID/ACCESS LINE	PROTOCOL SPECIFIC ADDRESS	
	HEADER TYPE	ADDRESS IN HEADER
XXXX1/1	UDP HEADER	CMIP PORT
XXXX1/2	IPX HEADER	CMIP SOCKET
XXXX1/3	DDP HEADER	CMIP SOCKET/NAME
XXXX2/1	UDP HEADER	PORT 160/161
XXXX2/2	IPX HEADER	SOCKET 900F/9010
XXXX2/3	DDP HEADER	SOCKET 8/9 - SNMP AGENT/SNMP TRAP HANDLER

901 903 904

FIG. 9B

ACCESS ID/ACCESS LINE	PROTOCOL SPECIFIC ADDRESS	
	HEADER TYPE	ADDRESS IN HEADER
YYYY1/1	DDP HEADER	SOCKET 8/9 - SNMP AGENT/SNMP TRAP HANDLER
YYYY1/2	UDP HEADER	PORT 160/161
YYYY1/3	IPX HEADER	SOCKET 900F/9010
YYYY2/1	DDP HEADER	CMIP SOCKET/NAME
YYYY2/2	UDP HEADER	CMIP PORT
YYYY2/3	IPX HEADER	CMIP SOCKET

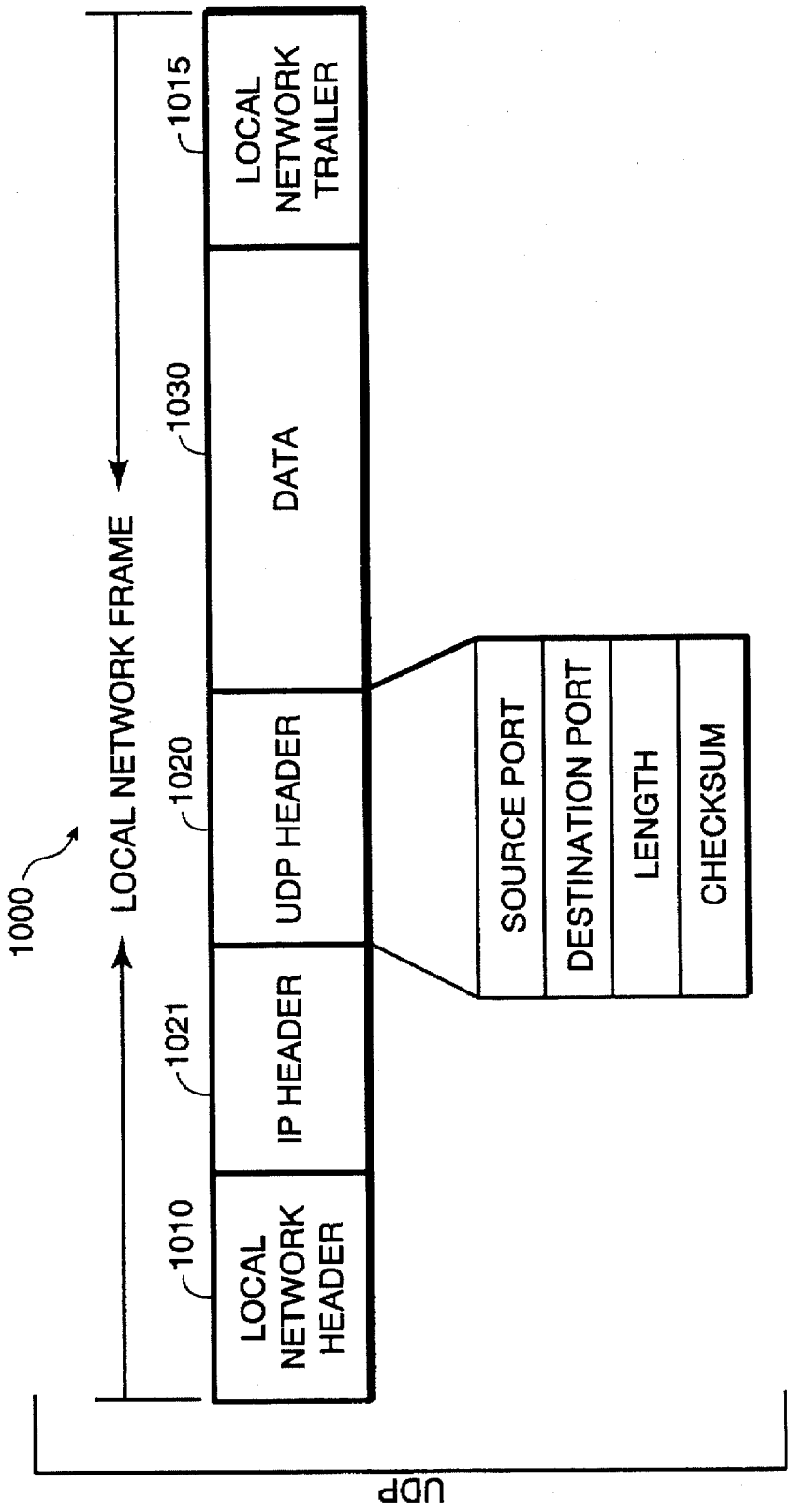
1000
LOCAL NETWORK FRAME
LOCAL NETWORK HEADER
1010
IP HEADER
1021
UDP HEADER
1020
DATA
1030
LOCAL NETWORK TRAILER
1015
UDP
SOURCE PORT
DESTINATION PORT
LENGTH
CHECKSUM

FIG. 10A

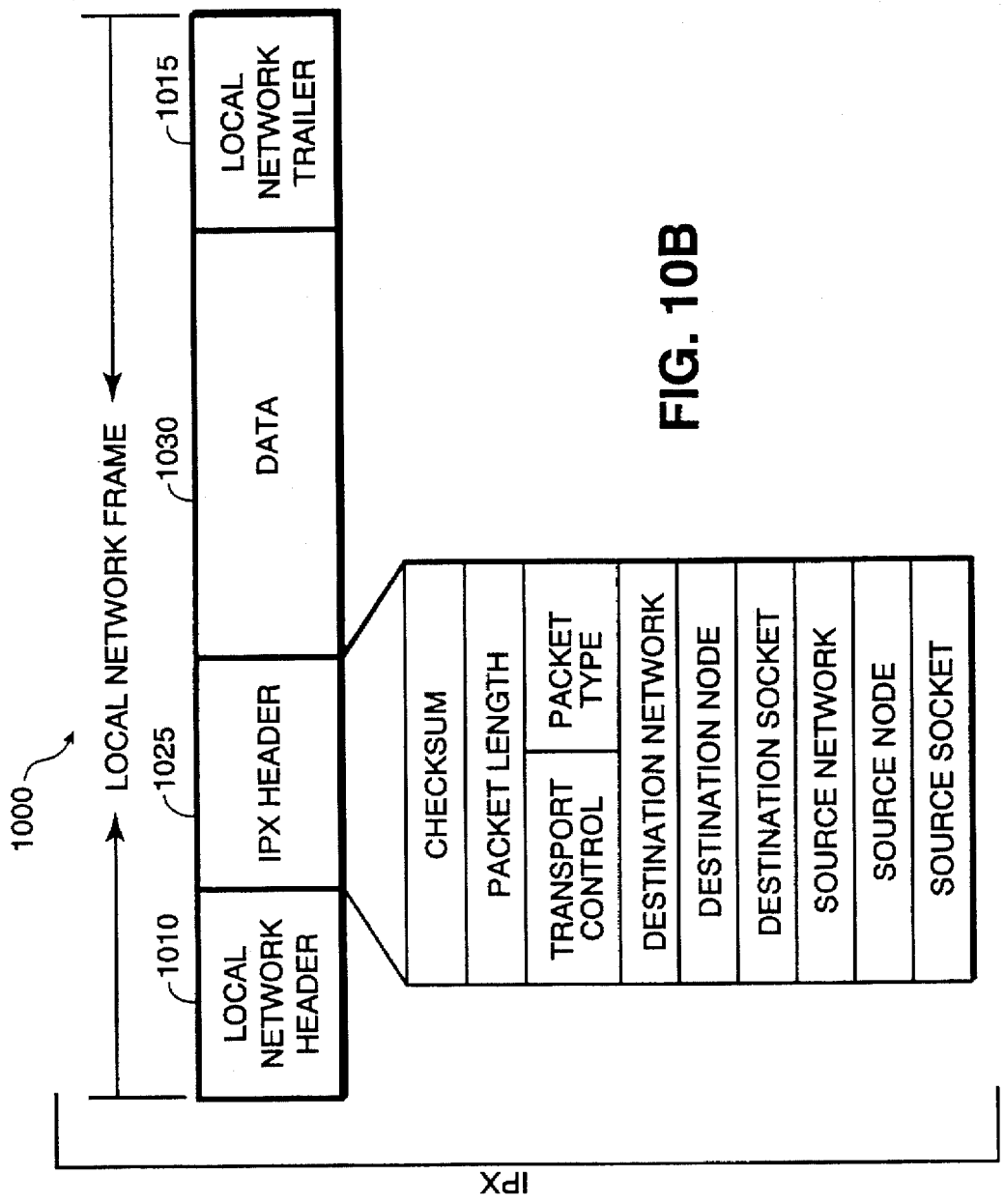
1000
LOCAL NETWORK FRAME
1010
LOCAL NETWORK HEADER
1025
IPX HEADER
1030
DATA
1015
LOCAL NETWORK TRAILER
CHECKSUM
PACKET LENGTH
TRANSPORT CONTROL
PACKET TYPE
DESTINATION NETWORK
DESTINATION NODE
DESTINATION SOCKET
SOURCE NETWORK
SOURCE NODE
SOURCE SOCKET
IPX

FIG. 10B

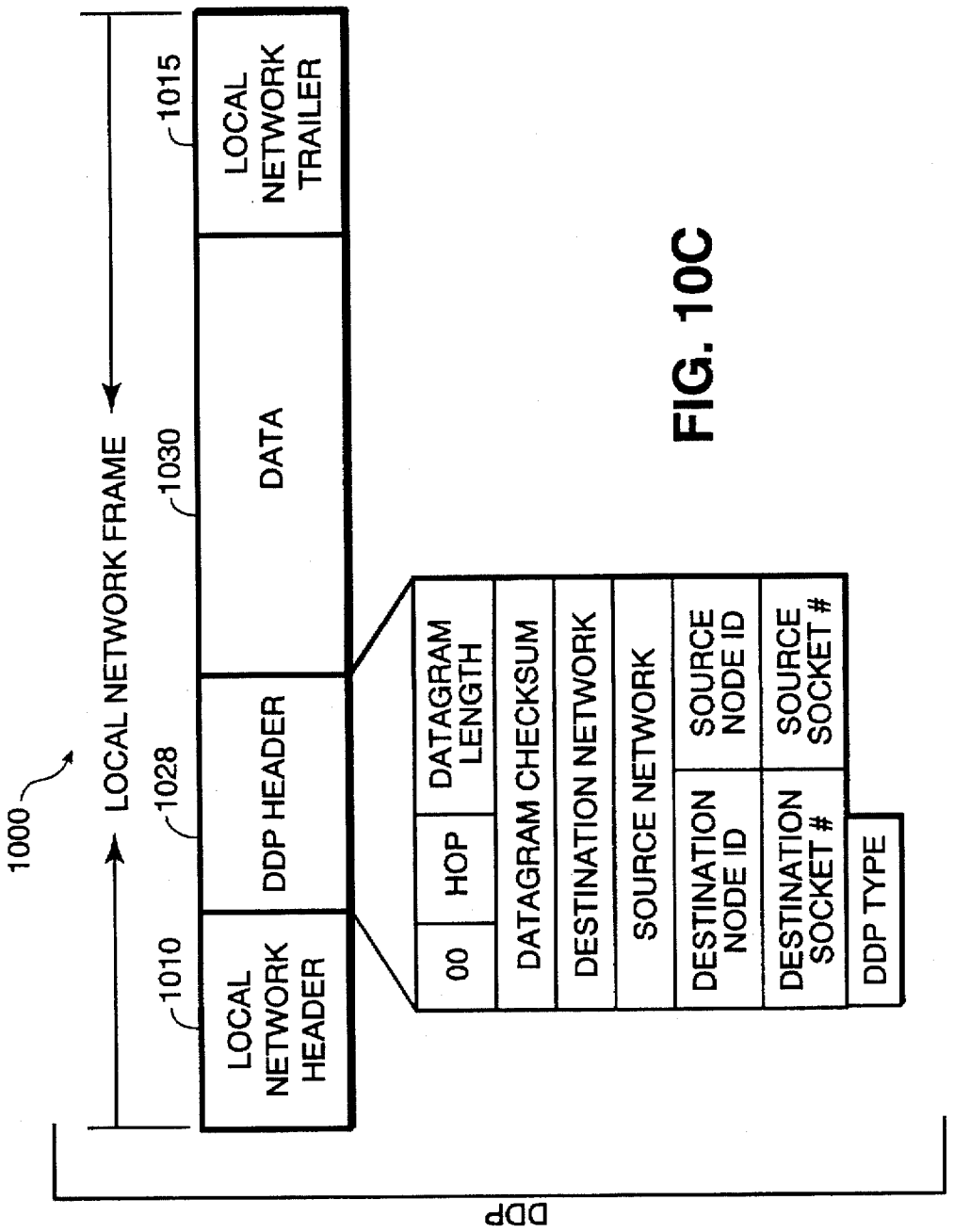
1000
LOCAL NETWORK FRAME
1010
LOCAL NETWORK HEADER
1028
DDP HEADER
1030
DATA
1015
LOCAL NETWORK TRAILER
00
HOP
DATAGRAM LENGTH
DATAGRAM CHECKSUM
DESTINATION NETWORK
SOURCE NETWORK
DESTINATION NODE ID
SOURCE NODE ID
DESTINATION SOCKET #
SOURCE SOCKET #
DDP TYPE
DDP

FIG. 10C

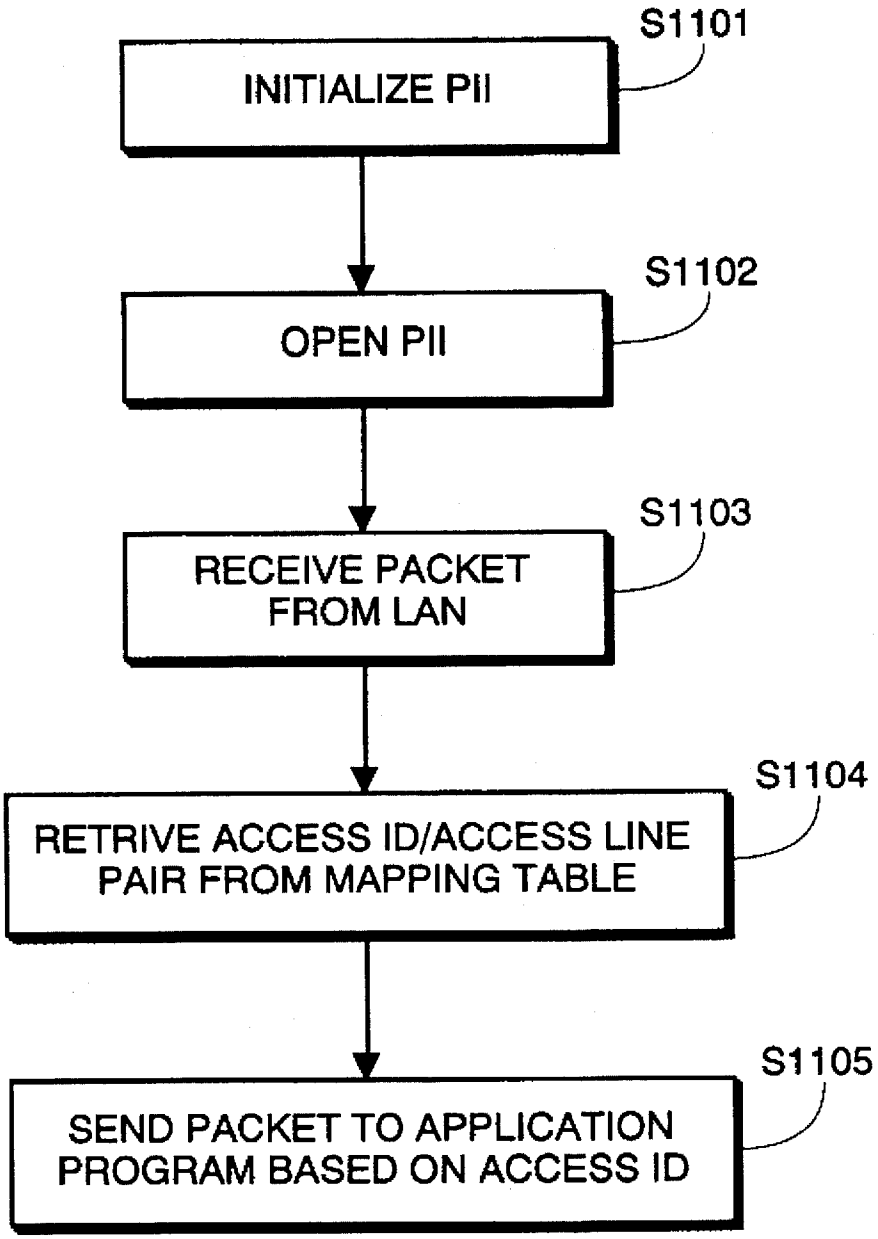
S1101
INITIALIZE PII
S1102
OPEN PII
S1103
RECEIVE PACKET FROM LAN
S1104
RETRIVE ACCESS ID/ACCESS LINE PAIR FROM MAPPING TABLE
S1105
SEND PACKET TO APPLICATION PROGRAM BASED ON ACCESS ID

FIG. 11

ADAPTIVE NETWORK PROTOCOL INDEPENDENT INTERFACE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of transmitting data between application programs executing on different devices interfaced to a local area network and, more particularly, to a method of transmitting data between application programs independent of any specific protocol.

2. Description of the Related Art

Computerized local area networks (LAN's) are in widespread use for interconnecting many different computers and peripherals so as to allow users of the computers to communicate with one another and also to allow those users shared access to the peripherals. Recent developments in LAN's have seen the introduction of so-called "heterogeneous" LAN's, i.e., LAN's on which many different communication protocols are carried on a single Ethernet or Token-ring medium. Examples of different protocols are IPX, which is typically used by DOS-based PC's, UDP/IP, which is typically used by UNIX-based workstations, and DDP, which is typically used by Macintosh computers. Each type of computer or workstation can be adapted through software to communicate using multiple different protocols.

A peripheral also can include software, i.e., multiple protocol stack modules, which allows the peripheral to communicate using multiple protocols in order to be shared on a heterogeneous LAN. A protocol stack is a software module that processes packets of data which are received from or are transmitted to the LAN using the corresponding protocol. The protocol stacks and the associated lower-level software for network communications are typically stored and executed on a network interface device which may be embedded in or attached to the peripheral. The network interface device serves as an interface which allows the peripheral to communicate with other network devices via the LAN.

Network devices, i.e., network interface devices and computers which are interfaced to the LAN, also execute application programs. These programs execute at a level above the protocol stacks and can include, for example, print server programs, management programs which allow communication between a computer and a peripheral in order to configure or obtain status data from the peripheral, and other programs which may communicate data between different devices interfaced to the LAN. Exemplary management programs include programs that implement SNMP (Simple Network Management Protocol) and CMIP (Common Management Information Protocol). More than one such management program may be executing on a single network device at the same time.

In a conventional approach, an application program communicates with a protocol stack via an application programming interface (API) and uses the protocol stack to perform communications services. An application program must use different APIs to interface with each different protocol stack. This means that the application program must be aware of the particular network environment, i.e., the protocol in use, and the specific network API to be used.

The conventional approach leads to many difficulties. If an application program must support multiple network protocols, duplicated effort is required for the application software to handle the different APIs. For example, an SNMP program must include software code to communicate with an IPX protocol stack and a DDP protocol stack, in addition to code to communicate with a UDP protocol stack. Moreover, a CMIP program or any other application will also require the extra code for communicating with different protocol stacks. As a result, application programs that are designed to support multiple protocols using the conventional approach require a more complex design, have a longer development time, have less portability, and have a higher maintenance cost than application programs which support a single protocol.

Accordingly, a way is needed for application programs to communicate with application programs on other network devices independent of a specific protocol.

SUMMARY OF THE INVENTION

The above need is addressed by the present invention in which data is transmitted between application programs executing on different devices independent of a specific protocol.

In a first aspect, the present invention is a protocol independent method of transmitting a data packet from a first application program executing on a first device which is interfaced to a LAN and a second application program executing on a second device which is interfaced to the LAN. A protocol independent interface (PII) program is initialized which determines which protocols are available for use, assigns an access line to each protocol available for use, assigns an access ID to the first application program, and creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data. A data packet is sent to the PII program together with the access ID of the first application program and a destination ID for the second application program, and one of the available protocols is selected to transmit the data packet. A block of protocol specific information is retrieved from the mapping information based on the access ID of the first application program and the access line corresponding to the selected protocol, and a transmission packet is formed which includes the data packet, the destination ID, and the retrieved block of protocol specific information. The transmission packet is then transmitted via the LAN.

By virtue of this arrangement, a generic interface is provided between application programs and protocol stacks, so that the protocol used to transmit data between application programs executing on different network devices is transparent, i.e., unknown to the application program. As a result, application programs can be written generally without including code to handle communication with different application programming interfaces for different protocol stacks.

In another aspect, the present invention is a method of delivering a data packet received from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN. A protocol independent data packet is received from the first application program, together with data identifying the first application program and a destination ID identifying the second application program. The protocols available for use are determined and one of the available protocols is selected to transmit the data packet. Protocol specific information which includes a protocol header having predetermined address data is determined based on the data identifying the first application program and the protocol selected

in said selecting step. A transmission packet is then formed which includes the data packet, the destination ID, and the determined protocol specific information, and the transmission packet is transmitted to the second application program via the LAN.

By virtue of this arrangement, a data packet which is received from one application program without any data specifying a protocol can be transmitted to another application program based only on information identifying the source and destination programs received from the one application program.

In yet another aspect, the present invention is a method of receiving data which is transmitted from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN. A protocol independent interface program is initialized which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns a unique access ID to the second application program, and (iv) creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data. A transmission packet is received from the LAN which includes data and a block of protocol Specific information including a protocol header having predetermined address data. The access ID/access line pair which corresponds to the block of protocol specific information contained in the received transmission packet is then retrieved from the mapping information, and the data contained in the received transmission packet is sent to the second application program based on the access ID retrieved from the mapping information.

By virtue of this arrangement, a received packet can be routed to the correct application program through a generic interface without the need for an application programming interface specific to a particular protocol and application program.

In still another aspect, the present invention is a network device which is interfaced to a local area network (LAN) and which transmits data from a first application program executing on said network device to a second application program executing on another device interfaced to the LAN. The network device includes a LAN interface for sending data to and receiving data from the LAN and a storage device which stores the first application program and a protocol independent interface program which (i) determines which protocols are available, (ii) assigns an access line to each available protocol, (iii) assigns an access ID to the first application program, and (iv) creates mapping information having a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data. The network device also includes a processor which (i) executes the first application program, (ii) initializes the protocol independent interface program, (iii) processes a data packet which is generated by the first application program by selecting a protocol to transmit the data packet, retrieving a block of protocol specific information from the mapping information based on the access line corresponding to the selected protocol and the access ID of the first application program, and forming a transmission packet including a destination ID for the second application, the data packet, and the retrieved block of protocol specific information, and (iv) transmits the transmission packet via the LAN.

By virtue of this arrangement, a network device can transmit data from an application program which it executes to an application program executing on another device in such a manner that the protocol used to transmit the data is transparent to the application programs.

According to still a further aspect, the present invention is a network device which is interfaced to a local area network (LAN) and which receives data that is transmitted from a first application program executing on another device interfaced to the LAN to a second application program executing on said network device. The network device includes a LAN interface for sending data to and receiving data from the LAN and a storage device which stores the second application program and a protocol independent interface program which (i) determines which protocols are available, (ii) assigns an access line to each available protocol, (iii) assigns an access ID to the second application program, and (iv) creates mapping information having a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data. The network device also includes a processor which (i) executes the second application program, (ii) initializes the protocol independent interface program, (iii) receives via said LAN interface a data packet which is transmitted by the first application program and which includes a block of protocol specific information, (iv) retrieves an access ID/access line pair from the mapping information which corresponds to the block of protocol specific information contained in the data packet, and (v) sends the data packet to the second application program based on the access ID retrieved from the mapping information.

By virtue of this arrangement, a network device can receive data from an application program and route the data to a destination application program in such a way that the protocol used to transmit the data is transparent to the application program receiving the data. As a result, an application programming interface that is specific to the protocol and the application program is not needed to receive data.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram of a local area network.

FIG. **2** is a diagram showing the software architecture used for communication between application programs according to the preferred embodiment of the present invention.

FIG. **3** is a diagram showing the functional relationships between software modules executing on a computer and a network interface device.

FIG. **4** is a functional block diagram of a network expansion board for interfacing a printer to a local area network.

FIG. **5** illustrates software modules that may be stored in memory on the network expansion board.

FIG. **6** is a flow diagram showing process steps for transmitting a data packet between a first application program executing on a first network device and a second application program executing on a second network device.

FIGS. **7A** and **7B** show examples of protocol mapping tables created by protocol independent interfaces.

FIGS. **8A** and **8B** show examples of access ID mapping tables created by protocol independent interfaces.

FIGS. **9A** and **9B** show examples of protocol address mapping tables created by protocol independent interfaces.

FIGS. **10A** through **10C** show examples of transmission packet formats for use with different protocols.

FIG. **11** is a flow diagram showing process steps for receiving a data packet transmitted from a first application program executing on one network device to a second application program executing on another network device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[1. System Overview]

FIG. **1** is an illustration of a heterogeneous network system including several different types of computers and several different peripherals to which the computers can share access. The present invention can also be used with devices connected to a homogenous network, i.e., a network in which every device uses the same protocol.

In FIG. **1**, LAN **10** is depicted as an Ethernet medium which has a bus-type architecture, but a Token-ring medium having a ring-type architecture can be used as well. Connected to LAN **10** are a PC **20** which serves as a system administrator's computer, a PC **30** which serves as a print server for printers **85** and **95**, a Macintosh computer **40**, a UNIX workstation **50**, and a generalized workstation **60** having a control unit **61** and a display **62**. A fileserver **70** allows shared access to a network disk **75**. A network expansion board (NEB) **100** allows shared access to a printer **105**, and a network expansion device (NED) **110** allows shared access to a printer **115**. In addition, a network interface board (NIB) **120** allows shared access to a copier **135** via a multiple device controller (MDC) **130**.

The present invention relates to communication between application programs executing on different network devices. A preferred form of the present invention is described below in the context of communication between PC **20** and NEB **100**. However, the present invention is applicable to computers and embedded network devices in general. Accordingly, the present invention can be applied to communication between other computers such as Macintosh computer **40**, UNIX workstation **50**, generalized workstation **60** and other network interface devices such as NED **110** (an example of which is described in copending U.S. patent application Ser. No. 08/489,116 filed on Jun. 9, 1995, and entitled "Outputting a Network Device Log File") and NIB **120** (an example of which is described in U.S. patent application Ser. No. 08/409,034, filed on Mar. 23, 1995, and entitled "Network Interface Board For Digital Copier", which is assigned to the assignee of the present invention).

The present invention also can be applied to communication between application programs executing on different computers that have the capacity to use multiple protocols. Moreover, the present invention is not limited to network applications, but instead can be used for devices having a direct connection through any bidirectional interface, e.g., a shared memory, a SCSI interface, an RS-1284 parallel interface, or the like.

[2. Software Architecture]

FIG. **2** shows the software architecture of program modules executing on a network device such as NEB **100**. Similar software executes on a computer such as PC **20**. A network interface driver **210** is the lowest level of software which interfaces with LAN **10** and handles sending and receiving of packets on LAN **10** by adding or stripping off packet frame headers. Network interface driver **210** includes a media-type specific component which is designed for either an Ethernet or a Token-ring network medium and includes a plurality of logical boards for respectively processing packets having different frame types. A multiplexer software module **220** serves as a multiplexer which routes packets between network interface driver **210** and one or more protocol stacks. Each protocol stack receives packets that use the corresponding protocol, determines what needs to be done with the packets, and routes the packets to the appropriate application programs for servicing. The preferred embodiment supports three protocol stacks: IPX stack **230**, UDP stack **231**, and DDP stack **232**. All of the protocol stacks might not be loaded on a particular device. Further, additional stacks for other protocols may be included. In the preferred embodiment, network interface driver **210**, multiplexer software module **220**, and protocol stacks **230–232** conform to the Open Data-Link Interface (ODI) specification described in "Open Data-Link Interface Developer's Guide for DOS Workstation Protocol Stacks", Version 1.10, Released by Novell, Inc., Mar. 18, 1992.

A protocol independent interface (PII) **250** serves as an interface between protocol stacks **230–232** and management application programs such as an SNMP application program **260** and a CMIP application program **270**. PII **250** "listens" for data packets addressed to particular sockets, i.e., addresses, and accepts those packets from the protocol stacks **230–232** for processing and forwarding to the application programs. Since SNMP program **260** and CMIP program **270** are executing on an embedded device, i.e., NEB **100**, those programs are "agent" programs. An agent program collects and stores data regarding the network interface device, i.e., NEB **100**, and the peripheral, i.e., printer **105**, and responds to commands sent using the associated network management protocol, e.g., SNMP or CMIP, from a related "manager" program executing on a computer.

For example, the following predetermined addresses are used in the preferred embodiment for receiving data packets using the SNMP network management protocol: (1) for IPX, "socket" $900F_H$ and 9010_H (agent socket and trap socket, respectively), (2) for UDP, "port" 160_H and 161_H, and (3) for DDP, a unique name "SNMP Agent" and "SNMP Trap Handler" and "socket" 8_H and 9_H (agent socket and trap socket, respectively). Data packets that are not addressed to a socket used by a management program are routed to other application programs. For example, a PSERVER program **245** receives data packets via an API **240**. Other application programs, including other management programs, can also be included.

FIG. **3** is a diagram showing the functional relationship between manager programs executing on PC **20** and agent programs executing on NEB **100**. As shown in FIG. **3**, PC **20** includes a protocol independent interface (PII) **255**, an SNMP manager **265**, and a CMIP manager **275**. During an initialization process described below, PII **255** assigns a unique identifier referred to as an access ID to each management program. The access ID may be, for example, the MAC address of the device together with an additional number to uniquely identify each of SNMP manager **265** and CMIP manager **265**. Reference numerals **281**, **282**, and **283** designate logical channels used by different respective protocols, such as IPX, UDP, and/or DDP. PII **255** assigns an identifier referred to as a "logical access line" to each of the protocols, i.e., logical channels **281–283**, during initialization. By dynamically assigning access IDs and logical access lines, the PII can be readily adapted to support later-developed protocols without affecting the existing functionality.

PII **250** in NEB **100** likewise assigns an access ID to each of SNMP agent **260** and CMIP agent **270** and assigns a logical access line to each of the protocols. However, since the access IDs and logical access lines are specific to the PII

that assigns them, the access IDs and logical access lines assigned by PII **250** in NEB **100** can differ from those assigned by PII **255** in PC **20**. For example, as shown in FIG. **3**, SNMP manager **265** has access ID #2 in PC **20**, but the corresponding agent in NEB **100**, i.e., SNMP agent **260**, has access ID #1. Similarly, as shown in FIG. **3**, PII **250** assigns logical access line #1 to logical channel **281**, which may correspond to an IPX protocol, for example, while PII **255** assigns logical access line #3 to the same logical channel/protocol.

PII **250** and PII **255** perform identical interface functions. However, there are some differences in implementation due to the different platforms on which these software modules execute. For example, since PII **250** executes on an embedded device, it is implemented as a TSR (terminate and stay resident) routine. On the other hand, SNMP manager **265** is a Windows based application and PII **255** is implemented as a Windows-based DLL (Dynamic Link Library). Other differences are indicated in the description below where appropriate.

[3. NEB Architecture]

FIG. **4** is a functional block diagram of NEB **100**. Broadly speaking, NEB **100** is an interactive network circuit board which couples printer **105** to LAN **10**, making printer **105** a responsive and interactive network member. NEB **100** includes a shared memory SRAM **200** which is used for bidirectional communications between NEB **100** and printer **105**. Printer **105** includes a printer interface card **220** (not shown) having a microprocessor **225** (not shown) that reads data from and writes data to SRAM **200**. Printer **105** also includes a printer engine **250** (not shown) connected to printer interface card **220**.

NEB **100** receives print data, status requests, and control commands from LAN **10**, transmits print data, status requests, and control commands to printer **105** for execution, and transmits status information back to LAN **10**. Thus, NEB **100** can perform not only RPRINTER remote printer services and PSERVER print server functionalities, but can also offer to network members whatever status and control features are available from the peripheral interface.

Power for all circuits is supplied to NEB **100** from a +5 V power source **398**. Power is provided from power source **398** to power converter **396** which provides −9 V power to a transceiver **390** and to power converter **397** which provides +12 V power to a flash EPROM **350** for "flashing" (i.e., reprogramming of the EPROM). Network and network interface control logic **340** is preferably a single 144-pin application specific integrated circuit (ASIC) that includes a network controller **330** and interface control logic **320**. Network controller **330** is an NCR macro-cell compatible with a National DP83902A "ST-NIC" Ethernet controller, the details of which can be found in National Semiconductor's *Local Area Networks Databook*, National Semiconductor p/n 400055, National Semiconductor, 1993. Network controller **330** is designed to interface with CSMA/CA-type (carrier sense multiple access with collision detection) local area networks.

Network controller **330** connects with RJ-45 connector **385** directly and with coaxial connector **395** through transceiver **390**, which is preferably a National Semiconductor DP8392 coaxial transceiver interface, the details of which can also be found in National's *Local Area Networks Databook*. Network controller **330** is also coupled to an 8 KB SRAM **380** that is used as an input/output packet buffer for Ethernet data. This memory should preferably have an access time of about 70 ns or less.

Interface control logic **320** provides an interface between network controller **330**, microprocessor **300**, and memory devices EPROM **350** and DRAM **360**. Interface control logic **320** also interfaces with non-volatile random access memory (NVRAM) **370**, which is a 256 byte serial electrically erasable/programmable memory used for initialization data storage during power cycling of printer **105**. Network and printer configuration parameters are written into NVRAM **370** when printer **105** is first installed onto the network to allow NEB software to recover the installation parameters after printer power has been cycled off and on.

Interface control logic **320** also couples with serial port connector **325**, which comprises a receive data pin **326** and a transmit data pin **327** that can respectively receive and transmit serial data streams for debugging purposes. Interface control logic **320** senses data present at the receive data line and samples the serial bits at regular intervals.

The central controller of NEB **100** is microprocessor **300**, which is preferably an Intel 80C188EA-20 8-bit processor, the details of which can be found in the 80C186EA/80188EA User's Manual, Intel p/n 270950-001, Intel Corp. This processor is an 8-bit processor with direct memory access (DMA), interrupts, timers, and a DRAM refresh control. Other microprocessors, such as an AMD 80C188-20 8-bit microprocessor, might alternatively be used. 256 KB flash EPROM **350** and 512 KB DRAM **360** are coupled to microprocessor **300** via interface control logic **320**, while 32 KB SRAM **200** (which is shared with printer interface card **220**) is coupled with microprocessor **300** via arbiter control logic **400**. A 40 MHz, 50 ppm crystal oscillator **310** provides microprocessor **300** with a clock signal that is wholly separate from and asynchronous with the clock signal provided to microprocessor **225** on printer interface card **220**.

Microprocessor **300** executes instructions in flash EPROM **350**, which stores control firmware and printing application software. After power-on self-test (POST), code from EPROM **350** is selectively moved to the higher performance 512 KB DRAM **360**, which should preferably have an access time of about 80 ns, for actual execution.

All communication between NEB **100** and printer interface card **220** is executed via 32 KB shared SRAM **200**. Arbiter control logic **400**, preferably a single 100-pin ASIC, arbitrates between the two-byte-wide memory accesses of printer interface microprocessor **225** and the single-byte-wide memory accesses of NEB microprocessor **300**, each of which is completely independent of the other.

Generally speaking, the 8-bit data bus of microprocessor **300** on board NEB **100** communicates with bus control logic **410**, while the 32-bit data bus of microprocessor **225** on board printer interface card **220** communicates with bus control logic **420**. Memory accesses from each bus are routed to shared memory arbiter **430**, which determines which bus has priority and permits the bus with priority to access SRAM **200** via SRAM interface **440**. Interrupt control register **450** is also accessed through shared memory arbiter **430**, to allow one microprocessor to interrupt the other.

All software modules executed by microprocessor **300** are stored in flash EPROM **350**. Those modules that are needed are selectively loaded from EPROM **350** into DRAM **360** and are executed from DRAM. This permits flexible configuration of NEB **100** by selection of which modules are to be loaded.

FIG. **5** illustrates an example of blocks of code, or software modules, that are stored in flash EPROM **350**. The PII module contains process steps for providing the required functions of a protocol independent interface, as described in more detail below. The XPL module provides a standardized interface between printer **105** and NEB **100**. MLID (Multi

Link Interface Driver) serves as network interface driver **210** and is a piece of Novell code (Media Support Module, or MSM) linked together with a piece of customized code (Hardware Support Module, or HSM) that is the lowest level of network connection, while LSL (Link Support Layer) serves as multiplexer software module **220** and is a piece of Novell code that acts as a multiplexer between the low level MLID and the several protocol stacks above it. CNETX is customized code that turns local DOS-like function calls into network function calls, providing file functions like OPEN, READ, WRITE, and CLOSE.

The PRETASK module is responsible for identifying what frame types are associated with the various possible protocol stacks. Because NEB **100** supports multiple protocol stacks, this module exists as long as NEB **100** is running.

Novell's IPX/SPX protocol stack is contained in flash EPROM **350**, and is supported by SAP, or Service Advertising Protocol. SAP is a Novell concept that allows devices to register themselves into the file server's bindery, which lists active and inactive network entities. Because print servers are a special kind of bindery item, SAP registers NEB **100** via CPSOCKET, and if NEB **100** is configured as a print server, SAP also registers the print server with the NetWare bindery.

CPSERVER is a custom implementation of a Novell print server application. This module provides self-generated print banners, user notification of completion and exception status, and transmission of print data and status commands to the printer. This differs from the Novell print server in that CPSERVER is dedicated to driving the local printer (i.e., printer **105** in which NEB **100** is installed) and cannot drive any remote RPRINTERs. This program owns the print data lines for the duration of a print job. CRPRINTER is a custom implementation of a Novell RPRINTER print application. This module is a slave application that is sent data by a Novell print server application elsewhere on LAN **10**.

The TCP/IP protocol stack has User Datagram Protocol (UDP), Reverse Address Resolution Protocol (RARP) and BootP support within. INTERRUPT is the interrupt handler for the TCP/IP task, while TIMERTICK is the timer tick for UNIX TCP/IP network tasks. LPRINTSERVER is the TCP/IP print server application, and also owns the print data lines for the duration of a print job. DDP is the module for implementing a Datagram Delivery Protocol (DDP) which is used, for example, for communications with a Macintosh computer.

The CPSOCKET program runs for all protocol stacks. The program responds to requests for connection, requests for data download, or requests for services from remote utilities, and provides status and control to other tasks via interprocess communication. Because CPSOCKET typically owns the status and control lines between NEB **100** and printer **105**, it is the only task that has the ability to obtain printer status via the status lines. CPSOCKET is responsible for the network connection and packet contents between the Novell-oriented status and control utilities (CPNET or the corresponding Windows version of client-based software utilities), or between the UNIX-oriented status and control utilities (CPUTIL).

MONITOR is a customized multi-tasking monitor which performs task creation, task destruction and microprocessor dispatch. MONITOR also has memory management submodules MEMGET and MEMFREE. RESIDENT is a block of routines that provides generic services such as read and write to flash EPROM **350**, FLASH code, ROM based debugger, hardware timer tick and other basic features. POST is a power-on self-test module that checks the integrity of NEB hardware and software at power-up.

Also stored in EPROM **350** is a network identification file (NIF) data block which stores board-invariant information, which is unique for every network board, hardware configuration data, board revision number and the like, as well as changeable information such as software version number. The information in the NIP data block is used to ensure that flash EPROM **350** is not reprogrammed with an incompatible firmware image.

Specifically, EPROM **350** stores "board" information such as model number, firmware level, and board revision number, as well as "network" information such as Media Access Control (MAC) address, which is unique for every network board, board name, network frame type, primary file server identification, queues serviced, network protocol, sampling frequency, PSERVER name, zone-name, and the like.

[4. Function of PII]

FIG. **6** is a flow diagram showing process steps for implementing a protocol independent method of transmitting a data packet from a first application program executing on a first device which is interfaced to a LAN to a second application program executing on a second device which is interfaced to the LAN. Briefly, according to FIG. **6**, a protocol independent interface (PII) program is initialized which determines which protocols are available for use, assigns an access line to each protocol that is available for use, assigns an access ID to the first application program, and creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data. This one-to-one mapping can be done by using a mapping table, as in the preferred form described below, or by implementing a data structure that carries the mapping information. A data packet is sent to the PII program together with the access ID of the first application program and a destination ID for the second application program, and one of the available protocols is selected to transmit the data packet. A block of protocol specific information is retrieved from the mapping table based on the access ID of the first application program and the access line corresponding to the selected protocol, and a transmission packet is formed which includes the data packet, the destination ID, and the retrieved block of protocol specific information. The transmission packet is then transmitted via the LAN.

More specifically, the process steps of FIG. **6** show transmission of a data packet from SNMP manager **265** on PC **20** to SNMP agent **260** on NEB **100**. The function of PII **250** to transmit a data packet from SNMP agent **260** to SNMP manager **265** is the same, with the only differences being the differences in implementation discussed herein. In step S**601**, SNMP manager **265** executes an initialization command to initialize PII **255**. This command must be executed prior to execution of any other PII commands and need only be performed once. As mentioned above, PII **255** is implemented in Windows as a DLL. Accordingly, in response to the initialization command, the necessary operations are performed to enable SNMP manager **265** to execute other PII commands using the DLL. In contrast, initialization of PII **250** by SNMP agent **260** in NEB **100** returns a table of entry points that SNMP agent **260** uses to call other PII routines.

PII **255** then determines which protocols are available for use by PC **20**. In the preferred embodiment, where PC **20** is operating in a Windows or DOS Novell-ODI environment, function calls which obtain an indication of the presence or absence of each protocol stack are issued in a round-robin

manner to determine which protocol stacks are available. Alternatively, commands to execute respective initialization routines for each protocol stack can be issued in round-robin fashion. If an initialization routine fails, the failure is interpreted to indicate that the protocol stack is not available at that instant. In the embedded platform, i.e., for PII **250** on NEB **100**, the pretask module has information regarding the available protocol stacks and that information is obtained and used by PII **250**.

After determining which protocols are available, PII **255** opens a socket for each available protocol depending on the type of protocol, and sets up a protocol mapping table. This table has a one-to-one correspondence between an access line and a type of protocol stack. As noted above, the mapping table is one of many possible implementations. For example, the protocol mapping also can be implemented as a bit map or some other data structure. The key is that there is a way of indicating a one-to-one correspondence between the access line and protocol stack. The mapping table used in the preferred embodiment is formed by assigning an access line to each available protocol and storing data indicating the access line assigned to each protocol in a section of memory reserved for use by PII **255**. FIG. **7**A is an example of a protocol mapping table that may be created by PII **255** when UDP, IPX, and DDP protocols are available, using the exemplary access line assignments shown in FIG. **3**.

After initialization of PII **255** in step **S601**, flow proceeds to step **S602** in which an Open command is executed by SNMP manager **265** to open a session. This command returns an access ID for a management program to use to identify itself, e.g., access ID #**2** for SNMP manager **265**. PII **255** stores data indicating the relationship between access IDs and management programs in the section of memory reserved for use by PII **255**. FIG. **8**A is an example of an access ID mapping table set up by PII **255** to indicate the relationship between access IDs and management programs. As with the protocol mapping table discussed above, the mapping between access IDs and application programs is capable of many implementations other than a mapping table, e.g., a bit map or other data structure. The data in FIG. **8**A corresponds to the exemplary assignment of access IDs shown in FIG. **3**. The access IDs are shown as XXXX1 or XXXX2, where XXXX represents the MAC address of PC **20** and the 1 and 2 indicate CMIP manager **275** and SNMP manager **265**, respectively. The purpose of an access ID is to uniquely identify different entities that utilize the PII, for example, CMIP manager **275** and SNMP manager **265**.

Flow next advances to step **S603** in which a data packet is sent to PII **255** from SNMP manager **265**. The packet is sent by providing a pointer to the packet's location in memory, together with the access ID for SNMP manager **265** and a destination ID for the packer's destination. Since no information indicating a transmission protocol is required for the packet, the packet is protocol independent and a single interface is provided between an application program and all protocol stacks. The destination ID of the corresponding agent, e.g., SNMP agent **260** corresponding to SNMP manager **265**, is determined in the preferred embodiment by performing a locate_agent function before data is sent to an agent. For example, in the case where Novell Netware is used, this function is performed by looking in a bindery in fileserver **70** to determine devices which are registered in the bindery, e.g., by using IPX's SAP function, and which may have compatible agents. Communication with those devices then takes place to obtain a destination ID for the agent. In a UNIX environment, the locate_agent function is performed by using predetermined host tables. In an AppleTalk environment, an agent is located using a unique name. Any other technique can also be used which allows the manager program to obtain a destination ID for an agent program.

After the packet is sent to PII **255**, flow proceeds to step **S604** in which a protocol is selected to transmit the data packet. If only one protocol is available, that protocol will be used. In the preferred embodiment, a protocol is selected by using a default or preferred protocol, if available. For example, UDP is the preferred protocol for transmitting data between SNMP manager **265** and SNMP agent **260**. If the preferred protocol is not available, then the first available protocol is used. However, there are many alternative variations for selecting a protocol to use. For example, a protocol can be selected randomly or the first available protocol can be used. Also, the protocol having the least traffic can be used. For example, in a Novell environment, library functions such as GetLocalTarget can return an estimate of the time required to deliver a 576-byte packet to a designated destination. These functions provide information related to network traffic using the corresponding protocol. A call to those functions can be used to obtain information indicating which protocol has the least traffic. Further, PII **255** can store a counter for each protocol (or access line) and can select the one that PII **255** has used the fewest times, or PII **255** can store a time at which each protocol (or access line) was last used and can select the one that was used least recently.

After selecting a protocol to transmit the data packet, flow advances to step **S605** in which PII **255** retrieves a block of protocol specific information, i.e., a protocol specific address, from a protocol address mapping table stored in memory. The information is retrieved based on the access ID of the transmitting program and the access line corresponding to the selected protocol. If the mapping table does not have an entry for the Access ID/Access line pair, for example, if the packet is the first packet transmitted by PII **255** for a particular manager using a particular protocol, an entry is added to the table.

FIG. **9**A illustrates an example of a protocol address mapping table created by PII **255**. There is a one-to-one correspondence between an Access ID/Access line pair and a protocol specific address. Reference numeral **901** designates a column of Access ID/Access line pairs. Reference numeral **902** represents a column of protocol specific addresses that each include a protocol header of a type indicated in column **903**. Each protocol header has a different format. The various protocol header formats are described in detail below with respect to FIGS. **10**A–**10**C. However, regardless of type, each protocol header includes some type of address data, e.g., a socket for an IPX header, a port for a UDP header, and a socket and name for a DDP header. Reference numeral **904** indicates a column showing the specific address data included in each protocol header.

The address data indicated in column **904** represents standard address data that is defined for use by a particular manager and protocol. For example, the SNMP protocol (access ID XXXX2 in FIGS. **8**A and **9**A) uses the following address data: (1) for IPX, "socket" $900F_H$ and 9010_H (agent socket and trap socket, respectively), (2) for UDP, "port" 160_H and 161_H, and (3) for DDP, a unique name "SNMP Agent" and "SNMP Trap Handler" and "socket" 8_H and 9_H (agent socket and trap socket, respectively). Likewise, the CMIP protocol uses specific address data such as a CMIP port for UDP, a CMIP socket for IPX, and a CMIP name and socket for DDP. An SNMP protocol packet and a CMIP protocol packet may have the same header type, but each

header will include different specific address data. For example, the protocol specific addresses shown in rows 1 and 4 of FIG. 9A each have a UDP-type header, but each header contains different address data as shown in column 904. If SNMP manager 265 has access ID XXXX2, as indicated in FIG. 8A, and the preferred protocol UDP is being used and has access line #1, as indicated in FIG. 7A, then the protocol specific address in the fourth row of FIG. 9A will be retrieved by PII 255, which corresponds to Access ID/Access line pair XXXX2/1.

If the present invention is used with application programs that do not have predefined sockets, standard identification values must be defined for those application programs and the PIIs used with both manager and agent programs must be programmed to used those standard identification values.

As mentioned above, each type of protocol header has a different format, as described with respect to FIGS. 10A–10C. FIG. 10A shows a format for a local network frame (or "transmission packet") 1000 when the frame is transmitted using a UDP protocol. In this case, network frame 1000 includes a local network header 1010 and a local network trailer 1015. It also includes an IP header 1021, a UDP header 1020, and data 1030. As shown in FIG. 10A, UDP header 1020 includes fields for a source port, a destination port, a length, and a checksum. FIG. 10B shows a format for network frame 1000 when the frame is transmitted using an IPX protocol. In that case, network frame 1000 does not include IP header 1021 and includes an IPX header 1025 in lieu of UDP header 1020. IPX header 1025 includes fields for a checksum, a packet length, a transport control value, a packet type, a destination network, a destination node, a destination socket, a source network, a source node, and a source socket. Lastly, FIG. 10C shows a format for network frame 1000 when the frame is transmitted using a DDP protocol. In this case, the network frame also lacks IP header 1021 and includes a DDP header 1028 instead of either UDP header 1020 or IPX header 1025. DDP header 1028 includes fields containing, 00, Hop, a datagram length, a datagram checksum, a destination network, a source network, a destination node ID, a source node ID, a destination socket number, a source socket number, and a DDP type.

Referring again to FIG. 6, after retrieving the protocol specific information, flow proceeds to step S606 in which PII 255 forms a transmission packet which is specific to the selected protocol, i.e., a network frame 1000 having one of the formats shown in FIGS. 10A–10C. The transmission frame is formed using the destination information provided by SNMP manager 265 and the information retrieved from the protocol address mapping table in step S605. Further, data 1030 is the data being sent by SNMP manager 265.

After forming transmission packet 1000, flow proceeds to step S607 in which transmission packet 1000 is transmitted to the destination application program via LAN 10.

FIG. 11 is a flow diagram showing process steps for receiving transmission packet 1000 at NEB 100. In step S1101, SNMP agent 260 issues a command to initialize PII 250. PII 250 must be initialized before it can receive data from LAN 10 or SNMP agent 260. As mentioned above, SNMP agent 260 obtains a table of entry points into routines of PII 250 upon initialization, and PII 250 determines which protocols are available by obtaining information from the PRETASK software module. FIG. 7B shows an exemplary protocol table that is set up and stored by PII 250 when UDP, IPX, and DDP protocols are available and access lines are assigned as shown in FIG. 3.

Flow then advances to step S1102 in which SNMP agent 260 issues a PII open command to obtain an access ID. FIG. 8B shows an exemplary mapping of access IDs to management agents that is set up and stored by PII 250, based on the exemplary assignment of access IDs shown in FIG. 3. In FIG. 8B, YYYY represents the MAC address of NEB 100. SNMP agent 260 is a passive entity which responds when SNMP manager 265 requests information but does not initiate communication. Accordingly, SNMP agent 260 listens for packets on all protocols that are available, i.e., packets addressed to any socket defined for SNMP use. Therefore, once an access ID is provided for an agent, e.g., SNMP agent 260, a mapping table is created with access ID/access line pair entries for every access line. FIG. 9B shows an exemplary protocol address mapping table for PII 250 based on the exemplary data in FIGS. 7A and 8A.

Flow then advances to step S1103 in which a transmission packet is received from LAN 10. Referring to FIG. 2, transmission packet 1000 is received from LAN 10 by network interface driver 210 and is routed to multiplexer software module 220 and then to one of protocol stacks 230–232. For example, when transmission packet 1000 represents data sent from SNMP manager 265 to SNMP agent 260 using the preferred UDP protocol, transmission packet 1000 is routed to UDP protocol stack 231. PII 250 listens for packets addressed to specific sockets, e.g., sockets defined for use by management programs, and ignores all others. Since transmission packet 1000 is addressed to one of the sockets to which PII 250 listens, PII 250 will receive the packet.

Flow then advances to step S1104 in which PII 250 obtains an Access ID/Access line pair based on protocol specific information 1020 in transmission packet 1000 by referring to the protocol address mapping table for PII 250 shown in FIG. 9B. For exemplary transmission packet 1000, Access ID/Access line pair YYYY1/2 will be retrieved from row 2 in FIG. 9B.

Flow then advances to step S1105 in which data 1030 is passed to the appropriate management program. This is done by referring to the access ID mapping information for PII 250, which is discussed above with reference to FIG. 8B. For example, Access ID YYYY1 corresponds to SNMP agent 260, so data 1030 of transmission packet 1000 is passed to SNMP agent 260.

Although an example has been described for transmitting data from a manager in PC 20 to an agent in NEB 100, the same process is applicable for transmitting data from NEB 100 to PC 20. Moreover, as discussed above, the present invention is not limited to transmission of data between management application programs and is not limited to network transmissions. Accordingly, while the preferred embodiment of the invention has been described, it is to be understood that the invention is not limited to the above-described embodiments and that various changes and modifications may be made by those of ordinary skill in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A protocol independent method of transmitting a data packet from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, said method comprising the steps of:

initializing a protocol independent interface program which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns an access ID to the first application program, and (iv) creates mapping information that indicates a one-to-one correspondence

between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data;

sending a data packet to the protocol independent interface program together with the access ID of the first application program and a destination ID for the second application program;

selecting one of the available protocols to transmit the data packet;

retrieving a block of protocol specific information from the mapping information based on the access ID of the first application program and the access line corresponding to the protocol selected in said selecting step;

forming a transmission packet including the data packet, the destination ID, and the retrieved block of protocol specific information; and

transmitting the transmission packet to the second application program via the LAN.

2. A method according to claim **1**, wherein said selecting step comprises determining whether a preferred protocol is available and selecting the preferred protocol if it is available.

3. A method according to claim **1**, wherein said selecting step comprises determining which of the available protocols has the least traffic and selecting the protocol determined to have the least traffic.

4. A method according to claim **1**, wherein said selecting step comprises determining which of the available protocols has been used least by the protocol independent interface program and selecting the protocol determined to have been used the least.

5. A method according to claim **1**, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, wherein said method further comprises the step of transmitting data packets including data to be serviced by the service routine.

6. A method of delivering a data packet received from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, said method comprising the steps of:

receiving a protocol independent data packet from the first application program, together with data identifying the first application program and a destination ID identifying the second application program;

determining which protocols are available for use on the LAN;

selecting one of the available protocols to transmit the data packet;

determining protocol specific information including a protocol header having predetermined address data based on the data identifying the first application program and the protocol selected in said selecting step;

forming a transmission packet including the data packet, the destination ID, and the determined protocol specific information; and

transmitting the transmission packet to the second application program via the LAN.

7. A method according to claim **6**, wherein said selecting step comprises selecting a preferred protocol if it is available.

8. A method according to claim **6**, wherein said selecting step comprises determining which of the available protocols has the least traffic and selecting the protocol determined to have the least traffic.

9. A method according to claim **6**, wherein said selecting step comprises determining which of the available protocols has been used least by the protocol independent interface program and selecting the protocol determined to have been used the least.

10. A method according to claim **6**, wherein the protocol independent interface program assigns a unique access ID to the first application program, assigns an access line to each available protocol, and creates mapping information having a one-to-one correspondence between each access ID/access line pair and a block of protocol specific information, and wherein said determining step comprises retrieving a block of protocol specific information from the mapping information based on the access ID of the first application program and the access line corresponding to the protocol selected in said selecting step.

11. A method according to claim **6**, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, wherein said method further comprises the step of transmitting data packets including data to be serviced by the service routine.

12. A method of receiving data which is transmitted from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, said method comprising the steps of:

initializing a protocol independent interface program which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns a unique access ID to the second application program, and (iv) creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data;

receiving a transmission packet which includes data and a block of protocol specific information including a protocol header having predetermined address data;

retrieving from the mapping information the access ID/access line pair which corresponds to the block of protocol specific information contained in the received transmission packet; and

sending the data contained in the received transmission packet to the second application program based on the access ID retrieved from the mapping information.

13. A method according to claim **12**, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, wherein said method further comprises the step of receiving data packets including data to be serviced by the service routine.

14. A network device which is interfaced to a local area network (LAN) and which transmits data from a first application program executing on said network device to a second application executing on another device interfaced to the LAN, said network device comprising:

a LAN interface for sending data to and receiving data from the LAN;

a storage device which stores an application program and a protocol independent interface program which (i) determines which protocols are available, (ii) assigns an access line to each available protocol, (iii) assigns an access ID to the first application program, and (iv) creates mapping information having a one-to-one correspondence between an access ID/access line pair and

a block of protocol specific information which includes a protocol header having predetermined address data; and

a processor which (i) executes the first application program, (ii) initializes the protocol independent interface program, (iii) processes a data packet which is generated by the first application program by selecting a protocol to transmit the data packet, retrieving a block of protocol specific information from the mapping information based on the access line corresponding to the selected protocol and the access ID of the first application program, and forming a transmission packet including a destination ID for the second application, the data packet, and the retrieved block of protocol specific information, and (iv) transmits the transmission packet via said LAN interface.

15. A network device according to claim **14**, wherein said network device is a network interface device which interfaces between a peripheral and the LAN, and wherein said processor executes a service routine, receives data packets including data to be serviced by the service routine via said LAN interface, and services the data using the service routine.

16. A network device which is interfaced to a local area network (LAN) and which receives data that is transmitted from a first application program executing on another device interfaced to the LAN to a second application executing on said network device, said network device comprising:

a LAN interface for sending data to and receiving data from the LAN;

a storage device which stores the second application program and a protocol independent interface program which (i) determines which protocols are available, (ii) assigns an access line to each available protocol, (iii) assigns an access ID to the second application program, and (iv) creates mapping information having a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data; and

a processor which (i) executes the second application program, (ii) initializes the protocol independent interface program, (iii) receives via said LAN interface a data packet which is transmitted by the first application program and which includes a block of protocol specific information, (iv) retrieves an access ID/access line pair from the mapping information which corresponds to the block of protocol specific information contained in the data packet, and (v) sends the data packet to the second application program based on the access ID retrieved from the mapping table.

17. A network device according to claim **16**, wherein said network device is a network interface device which interfaces between a peripheral and the LAN, and wherein said processor executes a service routine, receives data packets including data to be serviced by the service routine via said LAN interface, and services the data using the service routine.

18. Computer-executable process steps stored on a computer-readable medium, the computer-executable process steps to transmit a data packet from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, said computer-executable process steps comprising:

code to initialize a protocol independent interface program which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns an access ID to the first application program, and (iv) creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data;

code to send a data packet to the protocol independent interface program together with the access ID of the first application program and a destination ID for the second application program;

code to select one of the available protocols to transmit the data packet;

code to retrieve a block of protocol specific information from the mapping information based on the access ID of the first application program and the access line corresponding to the protocol selected in said selecting step;

code to form a transmission packet including the data packet, the destination ID, and the retrieved block of protocol specific information; and

code to transmit the transmission packet to the second application program via the LAN.

19. Computer-executable process steps according to claim **18**, wherein said code to select comprises code to determine whether a preferred protocol is available and code to select the preferred protocol if it is available.

20. Computer-executable process steps according to claim **18**, wherein said code to select comprises code to determine which of the available protocols has the least traffic and code to select the protocol determined to have the least traffic.

21. Computer-executable process steps according to claim **18**, wherein said code to select comprises code to determine which of the available protocols has been used least by the protocol independent interface program and code to select the protocol determined to have been used the least.

22. Computer-executable process steps according to claim **18**, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, and wherein the computer-executable process steps further comprise code to transmit data packets including data to be serviced by the service routine.

23. Computer-executable process steps stored on a computer-readable medium, the computer-executable process steps to deliver a data packet received from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, said computer-executable process steps comprising:

code to receive a protocol independent data packet from the first application program, together with data identifying the first application program and a destination ID identifying the second application program;

code to determine which protocols are available for use on the LAN;

code to select one of the available protocols to transmit the data packet;

code to determine protocol specific information including a protocol header having predetermined address data based on the data identifying the first application program and the protocol selected by said code to select;

code to form a transmission packet including the data packet, the destination ID, and the determined protocol specific information; and

code to transmit the transmission packet to the second application program via the LAN.

24. Computer-executable process steps according to claim 23, wherein said code to select comprises code to select a preferred protocol if it is available.

25. Computer-executable process steps according to claim 23, wherein said code to select comprises code to determine which of the available protocols has the least traffic and code to select the protocol determined to have the least traffic.

26. Computer-executable process steps according to claim 23, wherein said code to select comprises code to determine which of the available protocols has been used least by the protocol independent interface program and code to select the protocol determined to have been used the least.

27. Computer-executable process steps according to claim 23, wherein the protocol independent interface program assigns a unique access ID to the first application program, assigns an access line to each available protocol, and creates mapping information having a one-to-one correspondence between each access ID/access line pair and a block of protocol specific information, and wherein said code to determine comprises code to retrieve a block of protocol specific information from the mapping information based on the access ID of the first application program and the access line corresponding to the protocol selected by said code to select.

28. Computer-executable process steps according to claim 23, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, wherein said computer-executable process steps further comprise code to transmit data packets including data to be serviced by the service routine.

29. Computer-executable process steps stored on a computer-readable medium, the computer-executable process steps to receive data which is transmitted from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, said computer-executable process steps comprising:

code to initialize a protocol independent interface program which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns a unique access ID to the second application program, and (iv) creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data;

code to receive a transmission packet which includes data and a block of protocol specific information including a protocol header having predetermined address data;

code to retrieve from the mapping information the access ID/access line pair which corresponds to the block of protocol specific information contained in the received transmission packet; and

code to send the data contained in the received transmission packet to the second application program based on the access ID retrieved from the mapping information.

30. Computer-executable process steps according to claim 29, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, and wherein the computer-executable process steps further comprise code to receive data packets including data to be serviced by the service routine.

31. A computer-readable medium which stores computer-executable process steps, the computer-executable process steps to transmit a data packet from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, the computer-executable process steps comprising:

an initializing step to initialize a protocol independent interface program which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns an access ID to the first application program, and (iv) creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data;

a sending step to send a data packet to the protocol independent interface program together with the access ID of the first application program and a destination ID for the second application program;

a selecting step to select one of the available protocols to transmit the data packet;

a retrieving step to retrieve a block of protocol specific information from the mapping information based on the access ID of the first application program and the access line corresponding to the protocol selected in said selecting step;

a forming step to form a transmission packet including the data packet, the destination ID, and the retrieved block of protocol specific information; and

a transmitting step to transmit the transmission packet to the second application program via the LAN.

32. A computer-readable medium according to claim 31, wherein said selecting step comprises a determining step to determine whether a preferred protocol is available and a selecting step to select the preferred protocol if it is available.

33. A computer-readable medium according to claim 31, wherein said selecting step comprises a determining step to determine which of the available protocols has the least traffic and a selecting step to select the protocol determined to have the least traffic.

34. A computer-readable medium according to claim 31, wherein said selecting step comprises a determining step to determine which of the available protocols has been used least by the protocol independent interface program and a selecting step to select the protocol determined to have been used the least.

35. A computer-readable medium according to claim 31, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, and wherein the computer-executable process steps further comprise a transmitting step to transmit data packets including data to be serviced by the service routine.

36. A computer-readable medium which stores computer-executable process steps, the computer-executable process steps to deliver a data packet received from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, the computer-executable process steps comprising:

a receiving step to receive a protocol independent data packet from the first application program, together with data identifying the first application program and a destination ID identifying the second application program;

a determining step to determine which protocols are available for use on the LAN;

a selecting step to select one of the available protocols to transmit the data packet;

a determining step to determine protocol specific information including a protocol header having predetermined address data based on the data identifying the first application program and the protocol selected by said selecting step;

a forming step to form a transmission packet including the data packet, the destination ID, and the determined protocol specific information; and

a transmitting step to transmit the transmission packet to the second application program via the LAN.

37. A computer-readable medium according to claim **36**, wherein said selecting step comprises selecting a preferred protocol if it is available.

38. A computer-readable medium according to claim **36**, wherein said selecting step comprises a determining step to determine which of the available protocols has the least traffic and a selecting step to select the protocol determined to have the least traffic.

39. A computer-readable medium according to claim **36**, wherein said selecting step comprises a determining step to determine which of the available protocols has been used least by the protocol independent interface program and a selecting step to select the protocol determined to have been used the least.

40. A computer-readable medium according to claim **36**, wherein the protocol independent interface program assigns a unique access ID to the first application program, assigns an access line to each available protocol, and creates mapping information having a one-to-one correspondence between each access ID/access line pair and a block of protocol specific information, and wherein said determining step comprises a retrieving step to retrieve a block of protocol specific information from the mapping information based on the access ID of the first application program and the access line corresponding to the protocol selected by the selecting step.

41. A computer-readable medium according to claim **36**, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, and wherein the computer-executable process steps further comprise a transmitting step to transmit data packets including data to be serviced by the service routine.

42. A computer-readable medium which stores computer-executable process steps, the computer-executable process steps to receive data which is transmitted from a first application program executing on a first device which is interfaced to a local area network (LAN) to a second application program executing on a second device which is interfaced to the LAN, the computer-executable process steps comprising:

an initializing step to initialize a protocol independent interface program which (i) determines which protocols are available for use, (ii) assigns an access line to each protocol available for use, (iii) assigns a unique access ID to the second application program, and (iv) creates mapping information that indicates a one-to-one correspondence between an access ID/access line pair and a block of protocol specific information which includes a protocol header having predetermined address data;

a receiving step to receive a transmission packet which includes data and a block of protocol specific information including a protocol header having predetermined address data;

a retrieving step to retrieve from the mapping information the access ID/access line pair which corresponds to the block of protocol specific information contained in the received transmission packet; and

a sending step to send the data contained in the received transmission packet to the second application program based on the access ID retrieved from the mapping information.

43. A computer-readable medium according to claim **42**, wherein the second device is a network interface device which interfaces between a peripheral and the LAN and which executes a service routine, and wherein the computer-executable process steps further comprise a receiving step to receive data packets including data to be serviced by the service routine.

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